Fig. 12, Mature plant, zoospores escaping, sterile basal part limited by thin wall which is arched outward slightly because of the endosmotic pressure in the protoplast, and the removal of the pressure within the primary sporangium.
Fig. 13, One individual of *Harpochytrium* attacked by another, the parasitic one only half the size and age of the host individual.
Fig. 14, Later stage, showing degeneration of the host individual and the increased size of the parasitic individual.
Fig. 15, Mature individual attached at the side a short distance from the base.
Fig. 16, Mature individual attached at the end at a point between two adjacent *Spirogyra* cells.
Fig. 17, Same plant with zoospores escaping. This plant was kept in cell culture and the secondary sporangium from the sterile basal part began to grow before the developed zoospores escaped, and was forced out slightly at one side. The apex of individuals in Figs. 15, 16, show the peculiar condition shortly before formation of zoospores. In Fig. 17, amoeboid movement of some zoospores shown in the sporangium and also escaping.
Fig. 18, The zoospore after escaping from sporangium still showing amoeboid movement.
Fig. 19, Five individuals showing stages in attachment and elongation of zoospores. Figs. 6, 7, 11, 12, 13, 14, show the disk-like holdfast and absorbent disk between the outer and inner lamellae of cell wall.
Figs. 1–19 from specimens collected at Ithaca, N. Y.
Fig. 24, after Dangeard.

HARPOCHYTRIUM HYALOTHECAE Lagerheim.

Fig. 20, Showing two young individuals attached to cell of host (Hyalotheca dissiliens), one of the zoospores still within the slime and just having developed the slender stalk; the other individual, the zoospore having elongated and the outer end projecting beyond the slime sheath.
Fig. 21, Mature individual attacked by a filamentous bacterium.
Figs. 20, 21, from specimens collected at Ithaca, N. Y.
Fig. 25, after Gobi.
Fig. 26, after Lagerheim.

HARPOCHYTRIUM INTERMEDIUM Atkinson.

Fig. 22, Half grown individual attached to *Conferva utriculosa*, showing disk-like haustorium between outer and inner lamellae of cell wall.
Fig. 23, Mature individual with empty primary sporangium, and young secondary sporangium developing.
Figs. 22, 23, from material collected at Ithaca, N. Y.

CULTURES OF UREDINEAE IN 1903.[1]

J. C. ARTHUR.

The present article forms the fourth of a series of reports[2] by the author upon the cultures of plant rusts. They cover the years from 1899 to the present inclusive. This report is devoted both to autoecious and heteroecious species, among which the grass and sedge rusts have had a prominent place. The number of species studied and the number of cultures made have fallen off somewhat from last year, partly because it was late in the spring before assistance was secured to carry on the work, and partly because a less number of collections of teleutospores and field observations were obtained upon which to base the work. The results however, fully equal in interest and importance those of last year, or possibly exceed them.

The expense of additional assistance in carrying on the work, and to some extent the expense of procuring material, was

[1] Read before the Botanical Society of America, St, Louis, December 30, 1903.

[2] See Bot. Gaz. *29*:268-276; Jour. Mycol. *8*:51-56; and Bot. Gaz. *35*:10-23.

borne this year in part by the Indiana Experiment Station and in part by a grant from the Botanical Society of America. By this means I was enabled to have the services of Mr. J. Clyde Marquis, an undergraduate student of the university, who made part of the preliminary drop cultures and attended to the microscopical technique, and of Mr. Fred J. Seaver, a graduate of Morningside College, Sioux City, Iowa, and a fellow in botany at the University of Iowa, who made most of the sowings and drop cultures and kept the records. The most active period for this work extends from the middle of April to the middle of June, while a smaller portion of the work extends through the remaining months of the year. The grant from the Botanical Society also permitted systematic field observations at Fair Oaks in the oak barrens of northern Indiana, where many species of rusts abound, for the most part unlike those occurring at Lafayette where the chief field observations heretofore necessarily have been made. These excursions into an unworked locality resulted in the discovery of the Andropogon-Comandra combination, the undescribed Carex-Solidago combination, and the autoecious character of the wide-spread Lespedeza rust, as well as minor items.

During the present season 68 collections of material were employed, and 217 drop cultures were made from them to test the germinating condition of the spores. Out of these 26 collections refused to germinate, and were consequently useless. There were in all 215 sowings of spores made, representing 32 species of rusts, and for this purpose were required 72 species of hosts temporarily grown in pots in the greenhouse. As in previous years success was attained in no case except when definite clues derived from field observations were in hand.

In order to provide ample resources, as far as possible, so that whatever suggestions are obtained even late in the season can be tested without delay, a stock of teleutosporic material is laid in of any species obtainable. In consequence there are always some species on hand in germinating condition with no definite guide for their use. So far as time permits these are sown upon any hosts known to bear aecidia in the region where the rust abounds. The results so far have been confined wholly to the negative information that the aecidia could not be produced on certain hosts. The following is a record of such blind attempts made during 1903. Teleutospores were employed in every case.

1. UROMYCES ACUMINATUS Arth. on *Spartina cynosuroides* Willd. from Fair Oaks, Ind., was sown on *Hydrophyllum appendiculatum,* with no infection.

2. PUCCINIA POLYGONI-AMPHIBII Pers. on *Polygonum emersum* (Michx.) Britt. from Columbus, Ohio, and Fair Oaks,

Ind., was sown on the same host and on *Cicuta maculata,* with no infection. Last year this rust was sown on two other species of *Polygonum* without infection. Recently the preliminary announcement of rust cultures for the season of 1903 by Dr. W. Tranzschel of St. Petersburg has been published. He states that infection was secured on *Geranium,* showing that the widely distributed *Aecidium sanguinolentum* Lindl., commonly found on *Geranium maculatum* in America, is the alternate form of this rust. My own observations in the field all go to affirm the correctness of this result.

3. PUCCINIA on *Carex Pennsylvanica* Lam. from Red Cloud, Neb., and Fair Oaks, Ind., was sown on *Aster paniculatus, A. Drummondii, A. prenanthoides, Solidago rigida, S. canadensis, Xanthium Canadense, Silphium perfoliatum, Ribes Cynosbati, R. aureum, Geranium maculatum, Viola cucullata,* and *Onagra biennis,* with no infection.

4. PUCCINIA on *Carex gravida* Bailey from Red Cloud, Neb., was sown on *Aster Drummondii, A. paniculatus, Senecio obovatus, Boltonia asteroides, Silphium perfoliatum, Ambrosia trifida, Xanthium Canadense, Cleome spinosa, Sambucus Canadensis, Ribes Cynosbati, Xanthoxylum Americanum,* and *Onagra biennis,* with no infection.

5. PUCCINIA on *Elymus Canadensis* L. from Red Cloud, Neb., was sown on *Impatiens aurea, Symphoricarpos racemosus,* and *Napaea dioica,* with no infection. There are various reasons, of which the above is one, for thinking that the rust on the several species of Elymus, occurring east of the Rocky Mts., which has heretofore been referred to one species really belongs to several species.

6. PUCCINIA VEXANS Farl. on *Bouteloua curtipendula* (Michx.) Torr. from Red Cloud, Neb., was sown on *Cleome spinosa, Physalis heterophylla, Physalodes Physalodes, Cassia Chamaecrista,* and *Pentstemon hirsutus,* with no infection.

7. PUCCINIA TOSTA Arth. on *Sporobolus neglectus* Nash from Red Cloud, Neb., was sown on *Oxalis cymosa, Ceanothus Americanus, Symphoricarpos racemosus, Cassia Chamaecrista, Callirrhoe involucrata, Xanthoxylum Americanum, Cleome spinost,* and *Aster ericoides,* with no infection.

8. PUCCINIA EMACULATA Schw. on *Panicum capillare* L. from Fair Oaks, Ind., was sown on *Aster prenanthoides, A. Drummondii, Solidago rigida, Lactuca Canadensis, Eupatorium perfoliatum, Xanthium Canadense, Ambrosia trifida Apocynum cannabinum, Polemonium reptans, Ribes Cynosbati, Onagra biennis, Anemone Pennsylvanica,* and *Geranium maculatum,* with no infection.

Five species of rusts were successfully grown, that had been studied with success before, and reported upon by the writer and in part by other invesigators. Mention of them here serves to confirm previous work, and in two cases to give additional knowledge regarding hosts.

1. PUCCINIA IMPATIENTIS (Schw.) Arth.—Teleutosporic material of this species on *Elymus Virginicus* was obtained near Lafayette, Ind., and sown, May 13, on *Impatiens aurea.* On May 18, an abundance of spermogonia appeared, and on May 26, an equal abundance of aecidia began to show. This result confirms the work of last year.[3] The locality from which the teleutosporic material was obtained for this season's work is several miles from the one yielding material last year.

2. PUCCINIA AMPHIGENA Diet.—Teleutosporic material was obtained by the writer on *Calamovilfa longifolia* from the type locality at Chicago, Ill. A sowing was made on a mature leaf of *Smilax hispida,* May 23. Spermogonia appeared sparingly on May 29, but were not followed by aecidia. Another sowing was made on a partly grown leaf of the same host species, May 24, from which a great abundance of spermogonia began to appear on May 28, followed by an equal abundance of aecidia, June 5. Some question has been raised regarding the correctness of last year's work,[4] as the teleutosporic form is known from regions where it is thought that *Smilax* does not grow, but that the genuine *Puccinia amphigena* has its alternate form on *Smilax* can no longer be doubted.

3. PUCCINIA ANDROPOGONIS Schw.—Teleutosporic material on *Andropogon scoparius,* collected at Bloomington in southern Nebraska, was sent to Rev. J. M. Bates. It was sown on *Pentstemon hirsutus,* May 19, giving rise to abundant spermogonia on May 25, followed by aecidia on June 4. Previous cultures have been made by Mr. William Stuart and the writer,[5] and by Prof. W. A. Kellerman.[6] There can be no question that this is a wide-spread and common species in North America.

4. PUCCINIA ALBIPERIDIA Arth.—Teleutosporic material of this species on *Carex gracillima* was most opportunely sent from Racine, Wis., by Dr. J. J. Davis. Sowing was made April 21, on *Ribes Cynosbati,* from which abundant spermogonia appeared on April 30, followed by great numbers of aecidia on May 11. A sowing made at the same time on *R. floridum* gave no infection. Three days later a sowing made on *R. aureum* seemed to have made a slight growth, which, nevertheless, came to naught. A sowing on *R. Uva-crispa,* a cut branch being placed in a glass of

[3] Bot. Gaz. *35*:18. 1903.
[4] Bot. Gaz. *35*:20. 1903.
[5] Bot. Gaz. *29*:272. 1900.
[6] Jour. Mycol. *9*:10. 1903.

water in the laboratory in lieu of a potted plant, gave some spermogonia, but the leaf fell from the stem before the time for the appearance of the aecidia. It would have undoubtedly been a successful infection, had the conditions been favorable for maintaining the vigor of the host. This species is based upon cultures made by the writer[7] in 1901. Its exact standing is yet in some uncertainty, and probably can not be settled until the connection of the very common aecidium, or aecidia if more than one kind, on the several species of *Ribes* is ascertained. Dr. J. J. Davis[8] has expressed the opinion that the whiteness of the aecidial cups is probably due to the conditions under which they are grown, and that they are normally orange-colored and identical with the common form. But the facts can only be ascertained by cultural studies.

5. PUCCINIA HELIANTHI Schw.—Ample teleutosporic material was available in vigorous germinating condition, collected by Prof .W. A. Kellerman at Sandusky, Ohio, and by the writer at Fair Oaks, Ind. All of it was on *Helianthus mollis.* Sowings began on April 29, and continued at intervals until June 2, twenty cultures being attempted. The sowings on *H. strumosus, H. tuberosus, H. grosse-serratus, H. rigidus,* and *H. Maximiliani* gave no infection. The sowing on *H. tomentosus* gave a slight infection, a few spermogonia appearing but reaching no further development, although the leaves were young and the plants exceptionally vigorous. On *H. mollis* and *H. annuus* an exceedingly strong infection was produced, numberless spermogonia appearing, followed by well developed aecidia in great quantity. The first sowings on *H. mollis* were made May 6, the first spermogonia appearing May 16, and the first aecidia May 22 and 23. A second sowing was made May 29, giving spermogonia June 7, and aecidia June 16. The sowing on *H. annuus* was made June 2, showing spermogonia June 8, and aecidia June 17.

Cultures of the Helianthus-rust were made during the previous year's work,[9] employing spores from *H. grosse-serratus,* which were found to grow upon the same host and the similar *H. Maximiliani,* but not upon *H. strumosus.* Judging from the work of the two years, it appears possible to divide the Helianthus-rust into at least three series, for which the forms on *H. mollis, H. strumosus* and *H. grosse-serratus* may be taken as representatives respectively. Dr. E. Jacky[10] of Switzerland has made cultures, and has come to the conclusion that there are two species of Helianthus-rust, for which the names *P. Helianthi* Schw. and *P. helianthorum* Schw. are to be used. It seems to

[7] Jour. Mycol. *8*:53. 1902.
[8] Trans. Wis. Acad. Sci. *14*:88. 1903.
[9] Bot. Gaz. *35*:17. 1903.
[10] Centr. f. Bakt. *9*²:841. 1902.

me that the data are yet too meager to make it worth while to undertake to decide upon the nomenclature of the forms or species, which ever they may be called.

In addition to the foregoing results seven species of rusts were grown, establishing aecidial and teleutosporic connections, not heretofore recorded. The species are partly autoecious and partly heteroecious rusts.

1. MELAMPSORA MEDUSAE Thüm.—Teleutosporic material on *Populus deltoides* Marsh. was obtained in the vicinity of Lafayette, Ind., and although of inferior quality, for the poplar rust was not abundant in this region last year, it was sown on *Larix decidua* Mill. (*L. Europaea* DC.) April 28. After a rather long interval of 16 days I was surprised and gratified to observe the beginning of spermogonia (May 14) in good quantity; and five days later (May 19), the aecidia appeared, and proved to be a caeoma-form. A sowing on this host was tried last year[11] without infection, which is, however, easily accounted for by the fact that the host plants employed in 1902 were very feeble. For the supply of *Larix,* used this year I am indebted to the generosity of R. Douglas' Sons, proprietors of the Waukegan Nurseries at Waukegan, Ill. They sent without remuneration 25 very thrifty young larch, suitable for 6-inch pots, which made vigorous growth when brought into the greenhouse.

This species is the American representative of the European *M. populina* Lèv., both species having their aecidia on *Larix.* That the American form is specifically distinct from the European was pointed out by Klebahn[12] in 1899, the differences being especially marked in the form, size and markings of the uredospores, and in the apical thickening of the teleutospores. The American form may be characterized as follows:

MELAMPSORA MEDUSAE Thuem.

O. Spermogonia epiphyllous, numerous scattered, inconspicuous, pale yellow, papilliform, by vertical sections shown to be columnar or hemnispherical, raised above the surface, 40-55μ, in diameter.

I. Aecidia hypophyllous, numerous, scattered, small, less than .5 mm. in diameter, pale yellow; peridium absent; aecidiospores catenulate, globoid, 20 μ in diameter; wall colorless, nearly 3 μ thick, finely verrucose.

II. Uredospores amphigenous, or sometimes only hypophyllous, roundish, small, less than .5 mm. in diameter, early naked, somewhat pulverulent, orange yellow; uredospores oval, or obovate-oblong, 15-18 by 22-30μ usually flattened on opposite sides; wall colorless, 2.5-3μ, thick, or up to 10μ on the flattened sides, sparsely and evenly echinulate with fine papillae, except on the flattened sides which are smooth; paraphyses

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[11] Bot. Gaz. *35*:11. 1903.

[12] *Z*tschr. f. Pfl.-Kr. *9*:144. 1899.

usually numerous, peripheral, capitate, smooth, 40-50 μ long, head 14-20 μ broad.

III. Teleutosori amphigenous, or sometimes only hypophyllous, small, irregularly roundish and scattered, or somewhat coalescing, subepidermal, at first light reddish brown, becoming deep chocolate-brown; teleutospores prismatic, 12-14 by 30-44 μ, wall smooth, cinnamon-brown, uniformly thin, not thickened at apex.

Spermogonia and aecidia on *Larix*, but not yet collected. Uredo and teleutospores on *Populus deltoides* Marsh. (P. *Medusae* Benth., P. *Canadensis* Moench,, *P. monilifera* Ait., *P. angulata* Ait.), *P. grandidentata* Michx., *P. tremuloides* Michx., *P. balsamifera* L., *P. angustifolia* Jas., and *P. trichocarpa* Torr. & Gr. Common throughout the United States and Canada.

2. UROMYCES PHASEOLI (Pers.) Wint.—This is a very common rust on various species of *Phaseolus, Strophostyles* and *Vigna*. Nevertheless its aecidial form is rarely seen, and it has been suggested that the American form might be heteroecious. Material for the cultures was collected near Lafayette, on *Strophostyles helvola* (L.) Britt. (*Phaseolus diversifolius* Pers.). It was sown, May 1, on *Euphorbia commutata* Engelm., with no infection. On May 15, a sowing was made on *Strophostyles helvola,* which gave abundant spermogonia on May 26, and well developed aecidia began to appear on June 4. Five subsequent sowings were made, but owing to difficulty in keeping the host-plants in flourishing condition only two of these gave positive results, and even these were less abundant than in the first trial. The autoecious character of the American form, however, is well demonstrated. It should be said that the somewhat common aecidium on *Apios* and *Amphicarpa* holds a doubtful relation to the bean rust, and is better considered distinct until positive relationship is established.

3. UROMYCES LESPEDEZAE-PROCUMBENTIS (Schw.) Curt.—This is a wide spread, and often abundant rust, occurring on various species of *Lespedeza*. No aecidium has ever been found clearly associated with it. The small and inconspicuous *Aecidium leucospermum* B. & C., rarely collected, has been suggested as a possible alternate form, but not very confidently.

Excellent teleutosporic material was obtained by the writer at Fair Oaks, Ind., in March, on the upright stems of *Lespedeza capitata* Michx. It was not until late in May that a host-plant was well established in the greenhouse. A sowing of spores was made on May 28, the host being *L. capitata*. Infection resulted, but the development was slow, clearly due to inferior growth conditions. On June 14 the first spermogonia protruded, soon becoming exceedingly numerous, and on June 18, the minute, colorless aecidia began to appear in great numbers. The typical form of *Aecidium leucospermum* was the result.

4. PUCCINIA CAULICOLA Tr. & Gall.—Fine teleutosporic material of this species on the stems of *Salvia lanceolata* Willd. was

sent to me in March by Mr. Elam Bartholomew, from Rockport, Kans. Seeds of the host were also sent, from which young plants were grown for culture work. A sowing was made on April 27; on May 11, the spermogonia began to appear, and on May 18, the aecidia. One later sowing was also successful, but the host plants did not flourish, and the results were meager. The demonstration, however, proved ample to establish the autoecious character of the species.

The aecidium of this species is so rarely seen as to give rise to the conjecture that the species might not possess an aecidium. The species is usually listed under *Puccinia nigrescens* Pk. This specific name, however, belongs to the somewhat similar European species, as pointed out by Bubák, who unnecessarily bestowed the new name *P. Salviae-lanceolatae* upon the American form. The rust occurs commonly upon the leaves, but is so much more conspicuous upon the stems, especially after the leaves have partly or wholly fallen, that most collections show the caulicolous form only.

5. Uromyces on *Carex*.—A species of *Uromyces on Carex* was found at Fair Oaks, Ind., on March 22 in very great abundance, and in fine viable condition. The *Carex* grew in an open sandy woodland, but in a depression of the surface where water sometimes gathered during heavy rains. It grew in tufts over a half acre of ground, and belonged to two species, *C. lanuginosa* Michx., easily told from the abundance of last year's fruiting culms still present, and *C. varia* Muhl., which showed not a trace of last year's culms, and was determined from the fruiting of a plant transferred to the greenhouse, and verified by a subsequent visit to the locality on May 3. On this latter visit a careful search for aecidia was made in the vicinity of the rusted *Carex,* but a few young leaves of a *Solidago* with spermogonia were the only result. These were growing with leaves intermixed and well surrounded by the rusted *Carex*. This was a very doubtful clue, as the common *Solidago* aecidium is known to belong to a *Puccinia,* yet experience has taught that the most improbable clues are not to be despised when the evidence is direct. Before finding this clue, sowings of the rust on *Carex varia* had been made on *Viola Cucullaria, Isopyrum biternatum, Trillium recurvatum, Ribes Cynosbati* and *R. aureum* with no infection. After the clue was obtained it was sown on five species of *Aster* with no infection, and on five species of *Solidago* with abundant infection. The following is the record of the latter. Sown May 6 on *S. Canadensis* L., showing abundant spermogonia on May 14, and aecidia on May 22. A sowing May 26 on *S. serotina* Ait. gave first spermogonia June 5, and aecidia June 16, the results being especially good. An equally successful culture was made on each of the two hosts at subsequent dates. Positive but less flourishing cultures were made on *S. flexicaulis*

L. and *S. caesia* L., clearly in accordance with the vigor of the host plants, while a sowing on *S. rigida* L. wholly failed, the host showing a weak growth.

The above sowings were all made from material on *Carex varia.* The collection on *C. lanuginosa,* taken at the same time and place, appearing in every way to be the same species, and to be in equally viable condition, was sown under equally favorable circumtsances on *Silphium perfoliatum, Ribes Cynosbati,* five species of *Aster,* and on *Solidago rigida, S. serotina* and repeatedly on *S. Canadensis,* all with no infection.

Whether the failure to infect the *Solidago* was due to some undetected oversight in manipulation, or is an indication of specific or racial difference in the rust, is a matter for which the facts do not warrant an opinion.

It is not easy to determine if this rust has been previously described and named or not. Upon morphological grounds it is clearly distinct from *Uromyces caricina* E. & E. and *U. minutus* Diet., but it may be the same as *U. perigynius* Halst. It also agrees well with collections from Wisconsin[13] on *Carex gracillima* Schw., from Decorah, Iowa,[14] on *C. pubescens* Muhl., and from Greencastle, Ind.,[15] on what was taken to be *C. pubescens,* but which a re-examination shows to be almost certainly *C. virescens* Muhl. If the rust on *C. varia* and *C. lanuginosa* had shown the same cultural behavior, I would have been inclined to unite these several collections under one name. But realizing the need of advancing cautiously among a group of species where only the first step has been taken, it seems wiser to give a separate name to the form about which we have definite knowledge, and leave the others to be dealt with later. The rust on *C. varia* with its alternate form is therefore, characterized under a new name, as follows:

UROMYCES SOLIDAGINI-CARICIS nom. nov.

O. Spermogonia epiphyllous, in small groups on yellow spots, punctiform, honey yellow, subepidermal, in vertical section shown to be globose, about 115 μ in diameter; isticlar filaments free, 60 μ long.

I. Aecidia hypophyllous, in groups, often circinating, peridia pale, low cylindrical, margin revolute, lacerate; aecidiospores globoid, or slightly elongated, 13-16 by 14-18 μ; wall colorless, thin, 1 μ or sometimes a little more, minutely rugose.

II. Uredosori not seen; uredospores among the teleutospores oval or obovate, about 16 by 23 μ; wall thin, echinulate.

III. Teleutosori hypophyllous, round, oblong or sometimes elongated, pulvinate, early naked, firm, chestnut-brown; teleutospores obovate, 15-18 by 23-28 μ, rounded or obtuse above, narrowed below; wall smooth, thin, 1.5-2μ, apex greatly thickened, 6-10μ; pedicel slender, tinted, as long as the spore, or longer.

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[13] Trans. Wis. Acad. Sci. *9*:180. 1892. Same *14*:90. 1903.
[14] Bot. Gaz. *16*:226. 1891.
[15] Same, l. c.

The collection on *Carex varia* Muhl., made at Fair Oaks, Ind., March 22, 1903, is taken as the type, together with the result of the culture on *Solidago Canadensis* L. obtained by a sowing made June 3, and matured July 1, 1903, at which date it was placed in the herbarium. I would tentatively refer here the collections referred to above on *C. gracillima, C. pubescens, C. virescens* (?) and *C. lanuginosa,* leaving their exact status to be determined later.

The aecidium of this species does not appear to differ in any marked manner from that of *Puccinia Caricis-Solidaginis* Arth., although, perhaps, the spores are a trifle smaller. I have not, however, had opportunity of collecting it in the field, as the heavy spring rains flooded the type locality and prevented all subsequent development of the rust, so that in subsequent visits at different times during the season the most dilligent search failed to reveal any trace of it on either *Solidago* or *Carex.*

6. AECIDIUM PUSTULATUM Curt.—In early April, 1902, an observation was made at Spirit Lake, Iowa, that proved very puzzling for a time. On an open prairie, that had been burned over during the late fall, a small area showed *Comandra pallida* A. DC. with aecidia, and in contact with it *Andropogon scoparius* Michx. bearing uredo, of the characteristic thin-walled sort known to belong to the species with aecidium on *Pentstemon.* It was easy to find teleutospores on the grass leaves pressed into hollows, thus protected from the passing fire, and only in part germinated. These were collected and sown on *Pentstemon hirsutus* with no infection. A sowing was not made on *Comandra,* as no suitable growing plants were available. A similar observation was made again this year at Fair Oaks, Ind., and once more under circumstances that seemed to permit of no other inference but that the *Comandra* and *Andropogon* rusts were connected, highly improbable as it seemed. This time plants of *Comandra umbellata* (L.) Nutt. were secured. A sowing of teleutospores from *Andropogon furcatus* Muhl. was made on May 5, and spermogonia began to appear on May 16, but the host plant withered before time for aecidia to appear. A similar sowing was made on a more vigorous host, May 25, spermogonia appearing in great abundance May 30, and aecidia June 9. Another sowing of teleutospores from *A. scoparius* obtained in the same locality at Fair Oaks, was made on *Comandra umbellata* June 1, the first spermogonia appearing June 9, and aecidia June 19. Sowings of both sets of teleutospores were made twice on *Pentstemon hirsutus,* under the most favorable circumstances, with no infection. The conclusion is beyond all question, that a common rust on species of *Andropogon,* not readily distinguishable from *Puccinia Andropogonis* Schw., has its aecidia on *Comandra,* being identical with *Ae. pustulatum* Curt.

A rather careful study of the newly detected species appears to show that it is to be distinguished from *P. Andropogonis* Schw. by the very dissimilar aecidium, and by the pores of the uredospores, which number 5 to 8 and are distributed without order, while in *P. Andropogonis* they usually number 3, and are approximately equatorial. The name for the species should be PUCCINIA PUSTULATA (Curt.) nom. nov.

7. AECIDIUM RANUNCULI Schw. An exceedingly fortunate observation was made in May, within a few miles of Lafayette, Ind. On a somewhat shaded hillside, an area not exceeding ten feet long by three feet wide, attracted attention by the yellowness of the new vegetation. Looking closer, it was found that the growing mass was made up almost wholly of *Ranunculus abortivus* L. thickly covered with the *Aecidium Ranunculi* Schw., and an equal quantity of *Eatonia Pennsylvanica* (DC.) A. Gray, intermixed, not yet in flower, but every leaf covered with a light yellow uredo. No other rusts occurred for some distance around, and even none on the same hosts elsewhere in the locality.

Healthy plants of *Eatonia Pennsylvanica* were obtained from another locality, transferred to the greenhouse, and spores of *Aecidium Ranunculi* sown on the youngest leaves, May 13. From this sowing uredospores appeared on May 21, and characteristic teleutospores began to show June 3. Although the trial with teleutospores could not be made, yet the demonstration of the genetic relation of the two forms seems beyond question. A confirmatory observation upon the intimate association of the two forms in the field has been reported to me by Mr. E. W. D. Holway, from Decorah, Iowa.

This is one of the numerous grass rusts passing under the name of *Puccinia rubigo-vera.* It can not be called *P. Ranunculi,* as that name is preoccupied, and therefore, I propose the name

PUCCINIA EATONIAE nom. nov. (*Aecidium Ranunculi Schw.*)

O. Spermogonia hypophyllous, thickly scattered over large areas, preceding or among the aecidia, punctiform, honey-yellow, inconspicuous, subepidermal.

I. Aecidia hypophyllous, evenly scattered over large areas; peridia broad and short, recurved, finely lacerate; aecidiospores subglobose or elliptical, 15-22 by 18-25 μ; wall colorless, medium thick, 1.5-2 μ, minutely verrucose; mycelium perennial in the host.

II. Uredosori chiefly epiphyllous, on yellow spots, small, oblong, pale yellow, ruptured epidermis noticeable; uredospores obovate-globoid, 15-18 by 20-23 μ; wall thin when mature, about 1 μ, pale yellow, finely and evenly echinulate, pores 6-8, scattered.

III. Teleutosori chiefly hypophyllous and caulicolous, small, oblong to linear, covered by the epidermis; teleutospores oblong-clavate to linear-cuneate, 12-16 by 35-45 μ, truncate or rounded above, narrowed below, slightly or not constricted at the septum; wall smooth, light brown, thin, 1-1.5 μ, apex a litte darker and thicker, 3-4 μ; pedicel very short, colored; paraphyses none, or few.

8. AECIDIUM HYDNOIDEUM B. & C.—Coming upon some bushes of *Dirca palustris* L., the middle of June, that were conspicuous with great numbers of yellow aecidial spots, search was made for grass and sedge rusts in the vicinity. At one side, by a small ravine, was found a most luxurient growth of uredo upon *Bromus ciliatus* L., with last year's teleutospores on the dead radical leaves. The most distant bush of rusted *Dirca* was not over a hundred feet away.

As soon as suitable potted plants of *Bromus ciliatus* could be established in the greenhouse, aecidiospores from the *Dirca* were sown. The first sowing came to naught, as the host plant failed to grow well. A sowing on June 25 gave uredospores in abundance on July 4. Teleutospores were first observed on August 10, although they probably appeared somewhat earlier.

The success of this trial removes another rust from that limbo of grass forms passing under the name of *Puccinia rubigo-vera.* We may characterize the species as follows, under the name

PUCCINIA HYDNOIDEA (B. & C.) nom. nov. (*Aecidium hydnoideum* B. & C.)

O. Spermogonia amphigenous in small groups on large yellow spots, inconspicuous, punctiform.

I. Aecidia hypophllous, usually circinating about the spermogonia; peridia short, cylindrical, pale, margin slightly recurved, finely erose or torn; aecidiospores globoid or oblong-globoid, 11-15 by 14-19 μ; wall yellowish, thin, 1 μ, minutely and inconspicuously verrucose.

II. Uredosori chiefly epiphyllous, oblong, early naked, pulverulent, fuscous; uredospores globoid or obovate-globoid, 18-21 by 20-28 μ; wall brownish, thin, 1 μ, abundantly echinulate, pores 4 or more, scattered.

III. Teleutosori chiefly hypophyllous and caulicolous, small and numerous, oblong, covered by the epidermis; teleutospores linear-oblong, 13-18 by 30-50 μ, truncate or oblique above, obtuse or slightly narrowed below, not constricted at the septum; wall smooth, light brown, thin, 1-1.5 μ, thickened at apex, 4-7 μ; pedicel very short, colored; paraphyses none, or few.

This species, undoubtedly, does not embrace all the American rusts on Bromus. It is, doubtless, the common form east of the Rocky Mts. Probably the multicellular form, found in Wisconsin and Minnesota, *Puccinia tomipara* Trel., is distinct, although it has not yet been shown that such irregular multiplication of cells in the teleutospore is a permanent character.

SUMMARY.

The following is a complete list of successful cultures made during the season of 1903. It is divided into the two series: species previously reported by the writer or other investigators, and species now reported for the first time.

A. Species previously reported.

1. Puccinia Impatientis (Schw.) Arth. — Teleutospores from *Elymus Virginicus* L. sown on *Impatiens aurea* Muhl.

2. Puccinia amphigena Diet. — Teleutospores from *Calamovilfa longifolia* (Hook.) Hack. sown on *Smilax hispida* Muhl.

3. Puccinia Andropogonis Schw. — Teleutospores from *Andropogon scoparius* Michx. sown on *Pentstemon hirsutus* (L.) Willd.

4. Puccinia albiperidia Arth. — Teleutospores from *Carex gracillima* Schw. sown on *Ribes Cynosbati* L. and *R. Uva-crispi* L. (*R. Grossularia* L.)

5. Puccinia Helianthi Schw. — Teleutospores from *Helianthus mollis* Lam. sown on *H. mollis* Lam. and *H. annuus* L.

B. Species reported now for the first time.

1. Melampsora Medusae Thuem. — Teleutospores from *Populus deltoides* Marsh. sown on *Larix decidua* Mill.

2. Uromyces Phaseoli (Pers.) Wint.—Teleutospores from *Strophostyles helvola* (L.) Britt. sown on same host.

3. Uromyces Lespedezae-procumbentis (Schw.) Curt. — Teleutospores from *Lespedeza capitata* Michx. sown on same host.

4. Puccinia caulicola Tr. & Gall. — Teleutospores from *Salvia lanceolata* Willd. sown on the same host.*

5. Uromyces Solidagini-Caricis Arth.—Teteutospores from *Carex varia* Muhl. sown on *Solidago Canadensis* L., *S. serotina* Ait., *S. flexicaulis* L. and *S. caesia* L.

6. Puccinia pustulata (Curt.) Arth. — Teleutospores from *Andropogon furcatus* Muhl. and *A. scoparius* Michx. sown on *Comandra umbellata* (L) Nutt.

7. Puccinia Eatoniae Arth. — Aecidiospores from *Ranunculus abortivus* L. sown on *Eatonia Pennsylvanica* (DC.) A. Gray.

8. Puccinia hydnoidea (B. & C.) Arth.—Aecidiospores from *Dirca palustris* L. sown on *Bromus ciliatus* L.

Judging from the few instances that have come to my notice, the interest and importance of making observations upon proximity of aecidial and teleutosporic forms are not yet fully appreciated by American collectors of *Uredineae*. This is the most valuable method by which a reasonable conjecture can be made regarding the alternate connection of any one of the many scores of isolated aecidial forms, most of which are probably heteroeci-

* Successful cultures reported by Kellerman, Jour. Mycol. 9:27, Dec. 1903.

ous. Cultural work without such conjectures based on field observations are largely a waste of time, rarely leading to any positive information. The time to make observations is early spring, when the rusts first begin to show, mostly in April and May. Simple record of proximity is not especially important. The observations must show that the inference is well established, that the new growth of spores has come from germinating spores of another sort found near by. The ability to work out such an inference marks the logical and acute observer.

I desire to thank Messrs. Kellerman, Bates, Davis and Bartholomew for providing teleutosporic material, and also Mr. Holway for numerous favors. I have already mentioned the kindness of Messrs. R. Douglas' Sons in providing host plants; strong plants of *Callirrhoe involucrata* were sent by Mr. Bartholomew. My particular thanks, moreover, are due to the Botanical Society of America for providing funds by which the work could be prosecuted, not only in the laboratory but in the field. The observations at Fair Oaks, Ind., by far the most important of those made in a single locality, were rendered possible by the society's generosity.

Purdue University, Lafayette, Ind.

NOTES FROM MYCOLOGICAL LITERATURE. VIII.

W. A. KELLERMAN.

THE MYCOLOGICAL ARTICLES IN ANNALES MYCOLOGICI, VOL. I, No. 6, Nov. 1903, are as follows: The Genus Harpochytrium in the United States (Atkinson); Das Absterben der Stöcke der Johannis- und Stachelbeeren, verursacht von Cytosporina Ribis P. Magnus n. sp. (van Hall); Ueber die geographische Verbreitung der Meliola nidulans (Schw.) Cooke (Neger); Die Discomyceten-Gattung Aleurina Sacc. (Rehm); Urophlyctis hemisphaerica (Speg.) Syd. (Sydow); Mycotheca germanica Fasc. I (no. 1-50) Fasc. II (no. 51-100) (Sydow); Mycologische Fragmente (v. Höhnel); Eine Neue Puccinia auf Senecio (Dietel); Sur le Phytophthora infestans (Matruchot & Molliard).

THE DAILY PROGRAM OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 53d Annual Meeting at St. Louis, last week in 1903, contained the following mycological papers: Cultures of Uredineae in 1903, J. C. Arthur; Uredineous Infections in 1903, W. A. Kellerman; Some Unusual Diseases of Plants in Iowa for the Season of 1903, L. H. Pammel; Symbiosis in Lolium, E. M. Freeman; A Lichen Society of a Sandstone Riprap, Bruce Fink; The Genus Harpochytrium; its Development, Synonymy and Distribution, G. F. Atkinson;